RoboCup2005
Rescue Robot League Competition
Osaka, Japan
July 13 – 19, 2005
www.robocup2005.org

RoboCupRescue - Robot League Team Sepanta (IRAN)

Mehdi Salmani Jelodar[1], Kambiz Ghaemi Oskouie[1], Neda Baheri[1], Masoud Labani[1], Ali Mashhadi[1], Hassan Asgharian[1], Mohammad Sepasi[1], Vahid Bazargan[1], Reza Zakery[1]

[1] Sepanta Robotic Research Foundation
Floor 1, No. 37, Rashtchi St, South Jamalzadeh St,
Azadi Ave, Tehran, Iran

m.salmani@srrf.net
http://www.srrf.net/projects/rescue/rescue-robot.asp

Abstract. In this paper the main features of the *Sepanta* Rescue Robot (KAVOSH) is described. Main ideas, plans and implementations will be addressed briefly, including sensory systems, control diagram, navigation and localization methods, manual map generation approach, robot locomotion and mechanical properties, overall control idea and our victim identification methods. The robot sensors set is very good for working in a disastrous site and its mechanical platform has a very good capability to negotiate through very rough surfaces. In this team description we tried to clarify our capabilities, ideas, plans and interests in rescue robot design and implementation.

Introduction

The ultimate goal of the RoboCup Rescue league is to develop autonomous systems that can be used in the time immediately following after a natural disaster, like earthquakes or similar calamities ([1], [2], [3]). Rescue Robot league aims to develop easy to use and extendable systems that can be used to assist human rescuers teams. In particular, such systems are supposed to be used right after the emergency starts, before aftershocks, where human operators must be extremely cautious but also extremely fast. The main scenario in real rescue robot: A building has partially collapsed due to earthquake; The Incident Commander in charge of rescue operations at the disaster scene, fearing secondary collapses from aftershocks, has asked for teams of robots to immediately search the interior of the building for victims. The mission for the robots and their operators is to find victims, determine their situation, state, and location, and then report back their findings in a map of the building and a victim data sheet. These will immediately be given to human rescue teams prepared to save all victims that are found. This decreases the risk for the operators and enhances the likelihood that the victim will be saved promptly. Because of the extreme difficulty associated with the problem, most entries nowadays are tele-operated. It seems, ultimately, autonomous processing will be of great importance in rescue and search robots. In rescue settings, issues such as operator fatigue, lack of situational awareness of the operator, cognitive load on the operator, and the number of individuals an operator can control in real time [4],[5] all place limitations on human control. And therefore we have focused on autonomy as a key focal point in our work in this project.

We have designed and implemented a real rescue robot called KAVOSH and have done plenty of research work to make it more autonomous as possible and ease its use and make it more reliable in rescue activities.

As rescue robots must works on a very bumpy, damaged and messy place and there is no prior initial knowledge about it. The main task is accomplished by giving KAVOSH a 'greedy' behavior to explore unexplored regions in the arena. This means that KAVOSH is continuously attracted towards zones which have not been visited yet. This task involves activities such: wall-following, door crossing, obstacle avoidance target approaching and… . A very robust and powerful mechanism is an unavoidable attribute for rescue robot. Therefore the mechanism of the robot is selected considering all limitations and possibilities and optimized for the highest dexterity: a four wheeled mechanism with bulldozer like actuation using an integrated mechanical brake. Rescue robot second task is carried out by robot's sensory devices: the camera, positioning devices (encoders, vision, digital compass, and accelerometers), ultrasonic sensors, CO_2 and CH_4 detection sensors, microphone, remote heat sensor, and … . While KAVOSH is moving, camera is capturing scenes and ultrasonic sensors show obstacles in robots neighborhood, and an ultrasonic sensor just aside main camera shows the distance of the object seen in the center of camera, while, localization tools demonstrate robot's location and a digital compass shows robot heading; Thus the exact position of the object is determined. Other sensors are used to identify found victim's situation and condition.

In other section you will see more about our implementation, ideas and plans in an overall view.

1. Team Members and Their Contributions

- Team Leader: Mehdi Salmani Jelodar
- Technical Manager: Kambiz Ghaemi Oskoie
- Mechanical design: Kambiz Ghaemi Oskoui, Abdollah Labani Motlagh, Mohammad Sepasi, Vahid Bazargan
- Controller and software development: Mehdi Salmani Jelodar, Hassan Asgharian, Ali Mashhadi, Neda Baheri, Reza Zakery

2. Operator Station Set-up and Break-Down (10 minutes)

KAVOSH set-up requires few steps to be performed. They consist on: turning on of both the operator and remote laptops. These steps allow the operator to gain control over the Robot and to start the exploration of the targeted arena. On top of the robotic platform we placed various devices (cameras, pan-tilt, video grabber, ultrasonic, and light diodes). They are all connected to the onboard laptop or controlled by it. KAVOSH is able to move very easy by an operator (we are working on it's power to carry operator with it self it means operator can seat on it and move with it).

3. Communications

The laptop mounted in the KAVOSH is equipped with an 802.11a/g wireless PCMCIA device (D-Link DWL-AG650 WLAN Wireless Laptop Card). This provides access to all the on-board activities via a remote monitoring using an operator laptop which is connected in a peer-to-peer fashion with the KAVOSH laptop. We are going to use standard C class 192.168.20.x addresses. More information about our wireless network card is in [6].

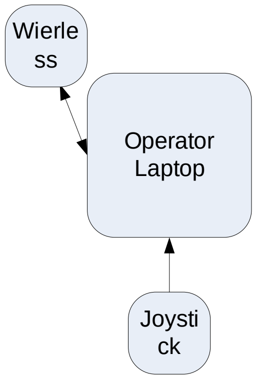
Rescue Robot League		
Sepanta (IRAN)		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	11	32 mW(15±2)
2.4 GHz - 802.11b/g	11	32 mW(15±2)

4. Control Method and Human-Robot Interface

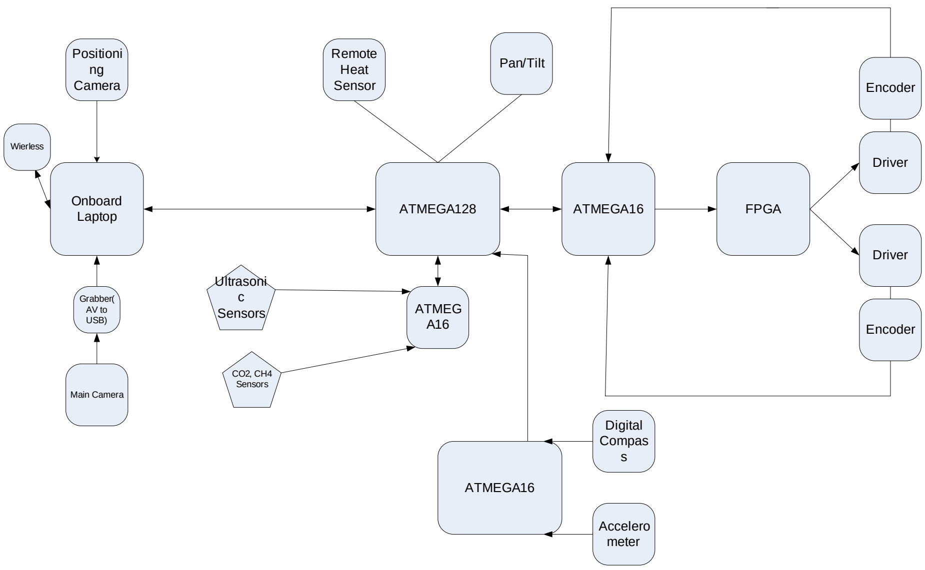
In our experiment the operator is directly connected to the onboard laptop. All operations run on the remote laptop. The operator has full access to the Remote desktop, in this way the operator sees everything KAVOSH sees (Of course we are working to make a robust connection and a software with a socket programming to reducing Remote-desktop overhead). Or, better, sees all what the remote application is programmed to show.
Our goal is to build a completely autonomous system, able to perform all tasks required in a Robocop rescue competition. Alternative operational modes are allowed.

The operator must perform navigation, victim identification and preparation of an environmental map. Control scheme and operator interface is through tele-operation. The operator uses a joystick and laptop which shows the received video and sensors data to control the robot motion.

The control sections (robot side and operator side) are demonstrated below:



Operator-side control system



KAVOSH- Internal control diagram

5. Map generation/printing

Our status in this section is stopped to our positioning method after that our plan is to generate map as semi-autonomous. In this approach (semi-autonomous) operator will trigged each important picture which received from robots main camera and other sensory information (position, distance, heat) and at the end by using these pictures and related data operator will print the map. Of course we are planning to make a data fusion on these data by computer. If we pass this phase successfully we will work on generating map automatically.

6. Sensors for Navigation and Localization

Localization is a very important and a bottleneck problem in mobile robots. There were many choices for localization of the robot, like dead reckoning, inertial navigation, land marks,…[1]. Several methods have been tested, but there were no perfect approach for rescue robot localization and finally we are working on fusion of encoder, vision and digital compass .and that was the process.

Inertial navigation was the first, we have tested. In this technique, by means of accelerometers and gyros the position of the robot is calculated by measuring the rate of rotation and acceleration of the robot. The block diagram of this method is shown in figure1.

Accelerometers measure small accelerations along the x or y axis of a robot. For measuring acceleration, we use the MEMS accelerometer ADXL202 [3]. They have extensive drift and are sensitive to bumpy ground, since the sensor will detect a component of the gravitational acceleration in bumpy ground. For omitting the earth's gravitational component, tilt sensors could be used. But, as the drift and its sensitivity were not acceptable we couldn't use it.

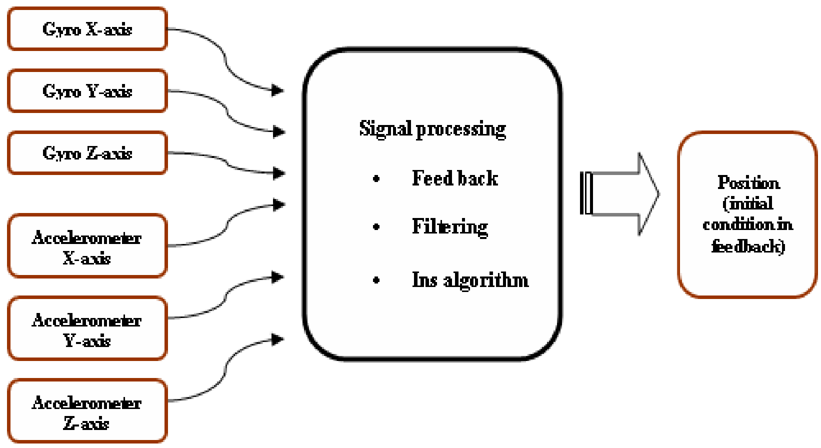


Figure 1: Inertial navigation method

The next method which was tested, is using a digital compass for measuring the yaw angle (the rotation angle of the robot from the North Pole), and shaft encoder for measuring the distance the robot has traveled by counting the number of revolution of each wheel. This method has some advantages to previous one and that is its short-term accuracy, but has a great defect and that is due to drift and slippage, the integration of the wheel revolutions leads to errors in both traveled distance and orientation. These errors accumulate over time. Another disadvantage of this method is its sensitivity. If the surface is not smooth and the robot has to climb obstacles, it can result in considerable position errors. For reducing the direction error measured by encoders, we used a digital compass CMPS03 from Acroname company [4] (Figure2). It measures the rotation angle of the robot from the North Pole by the accuracy of 1.169°. Its output angle is nearly accurate only if it is oriented horizontally. If it is tilted the direction angle must be calculated in inertial frame, so we use tilt sensors, ADXL202. By means of image processing we try to eliminate the error caused by slippage .A CCD camera is placed under the robot to get image from the path it is traveling. In case the two images were the same, the output data from the encoders will be ignored. The block diagram is shown in Figure 3.

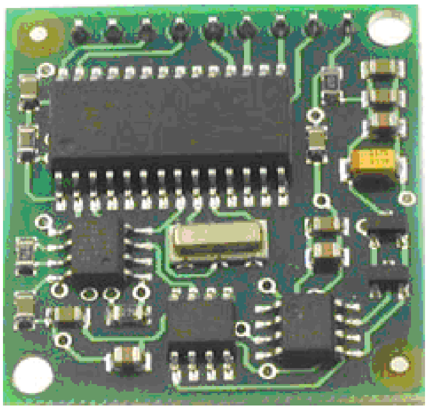


Figure 2: Acroname Digital Compass

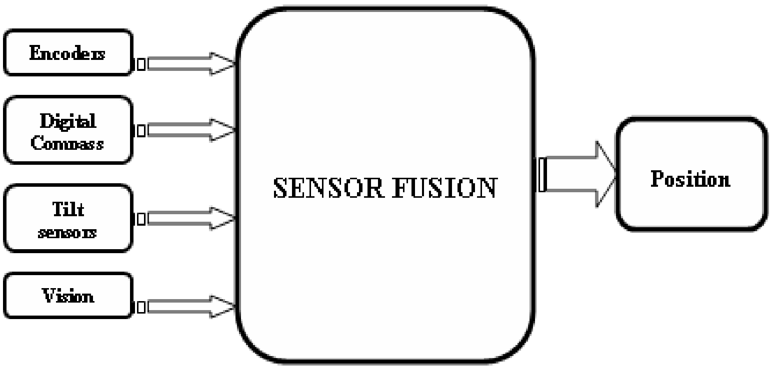


Figure 3: Elements of localization system

Now we are working on third approach and we hope to find the perfect or near perfect approach to our robot localization.

7. Sensors for Victim Identification

With robot camera, and ultrasonic rangefinder, remote heat sensor, CO2 detector and a microphone which will place in front of robot (on a manipulator) operator can detect victims' situation and state and its location. Operator can measure victims' temperature using a remote heat sensor which can provide object temperature remotely. It is placed beside the camera and rotates with it. It returns the temperature of the object in near the center of camera. It also checks audible signals using a microphone and send them to operator station (operator hear to environment audio through laptop speakers during rescue time) and it can see CO2 measure by using a Co2 detector which is on the head of manipulator in front of KAVOSH (of course we are working in this system). The distance between robot and victim will be measured using a sonar rangefinder sensor (SRF08) with the accuracy of 3cm (and consequently operator can calculate victims' location by using robot location and orientation); this sensor is also placed beside the camera and rotates with it (look likes thermal sensor) and our sonar accuracy is about 3cm and work on 6m.

8. Robot Locomotion

The locomotion system of KAVOSH is a four wheeled one. In order for easier motion of robot in highly rough areas a bulldozer like locomotion system is used. The wheels residing at the same side of the robot are powered synchronously using a timing belt. Also an integrated mechanical brake is considered via reducer gearboxes. The main body of robot is constructed using a light but hard alloy of Aluminum. Thus increasing the level of dexterity of robot. The difficulty rises upon turning which demands high power electromotors in this case a pair of 230W-24V-1800 rpm MOTRONICS motors are used. For best control logic, power is transmitted using 1:80 reducers providing mechanical brakes.

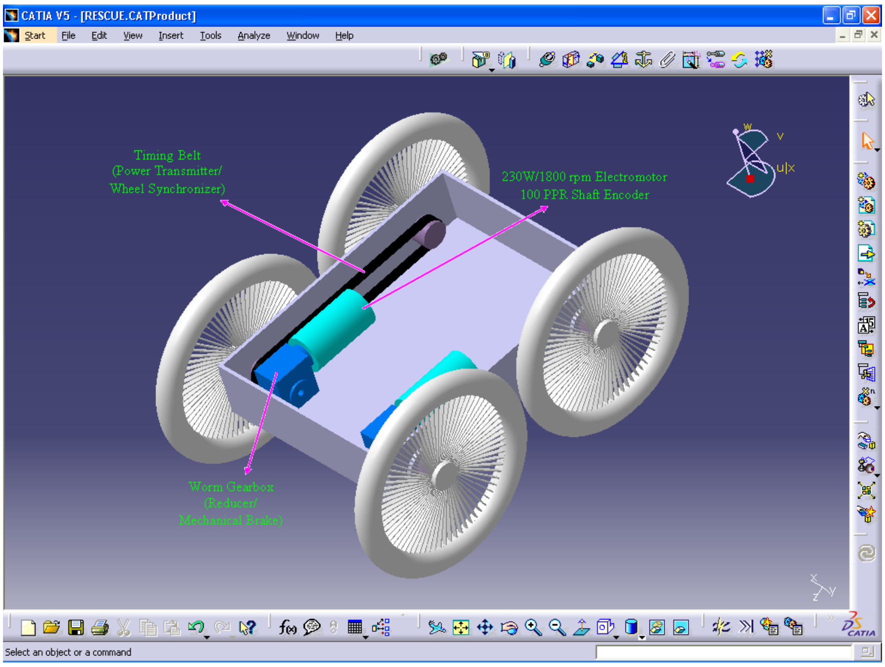


Figure 4: a simple model of the main structure

9. Other Mechanisms

For detection fire and probability of explosion a CO_2 detector on a manipulator to recognize victim's breath and a CH_4 sensor is provided on robot to report the air conditions of the disaster site. Also we are working on a system to carry out some first aides (injections and heart beat counting) by rescue robot.

10. Team Training for Operation (Human Factors)

We developed a user friendly application due to easy to use learning and trying to adding more feature and a user-friendly shell to make as easy as possible to working with these equipments but for becoming professional in it operator must train more with application, robot and equipments.

11. Possibility for Practical Application to Real Disaster Site

We designed and implement a reliable system and we think this robot can be used in a real disaster site (after completing our implementation). But it seems in a real disaster situation may be many other factors that we have not considered. The intensity of the disaster is also a very important factor to the usability of these systems. We are working on some other ideas to make these robots more useful and combining these robots with tele-medicine to make these robots more reliable and more realistic. We will publish as soon as possible our research results.

12. System Cost

TOTAL SYSTEM COST (per robot): 5000$ up to now.

KEY PART NAME: Motors
COST: 400$
DESCRIPTION/TIPS: 230W, 24V, 1800rpm

KEY PART NAME: Laptop
PART NUMBER: Pentium IV
MANUFACTURER: HP
COST: 1400$

KEY PART NAME: Atmega 128
MANUFACTURER: Atmel
COST: 10$
DESCRIPTION/TIPS: 128K Mem.,16MIPS, 64 pin.

KEY PART NAME: Atmega16
MANUFACTURER: Atmel
COST: 5$
DESCRIPTION/TIPS: 16K Mem., 8MIPS, 40 pin,

KEY PART NAME: Camera
MANUFACTURER: RockPINE
COST: 100$

KEY PART NAME: Camera
MANUFACTURER: Zolterix
COST: 50$

KEY PART NAME:	Grabber
PART NUMBER:	GA-VD200
COST:	80$

KEY PART NAME:	Ultrasonic
PART NUMBER:	SRF04, SRF08
COST:	36$, 60$

And some other mechanical part, several step motors, Remote heat sensor and ….

References

1. Kitano, H., Tadokoro, S.: Robocup rescue. a grand challenge for multiagent and intelligent systems. AI Magazine 22 (2001) 39–52
2. Takahashi, T., Tadokoro: Working with robots in disasters. IEEE Robotics and Automation Magazine 9 (2002) 34–39
3. Osuka, K., Murphy, R., Schultz, A.: Usar competitions for physically situated robots. IEEE Robotics and Automation Magazine 9 (2002) 26–33
4. Casper, J.: Human-robot interactions during the robot-assisted urban search and rescue response at the world trade center. Master's thesis, University of South Florida (2002).
5. Casper, J., Murphy, R.: Workflow study on human-robot interaction in usar. In: Proceedings of the IEEE International Conference on Robotics and Automation. Volume 2., Washington, DC, IEEE (2002) 1997–2003
6. http://www.dlink.com
7. J.C. Latombe, "Robot Motion Planning," Kluwer Academic, Boston MA, 1991.
8. J. Borenstein, "where am I? Sensors and Methods for Mobile Robot Positioning," H.R. Everett, L. Feng, University of Michigan, 1996.
9. http://www.analog.com/UploadedFiles/Data_Sheets/53728567227477ADXL202E_a.pdf, reviewed on 10 Feb-2005.
10. http://www.acroname.com/robotics/parts/R117-COMPASS.html, reviewed on 10-Feb-2005.

AppendiX: For more information about our robot please see our URL:
http://www.srrf.net/projects/rescue/rescue-robot.asp

A) Some of our robot pictures: